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(54) Data transmission

(57) A data transmission system suitable for use over an HF link affected by varying degrees of interference feeds data received and to be transmitted from a modem via an HF control unit which decodes or encodes it as required using a coding scheme which is governed by a code selector and which may be varied on the degree and type of interference on the link as sensed by information on errors located in the decoding units at each end of the link.

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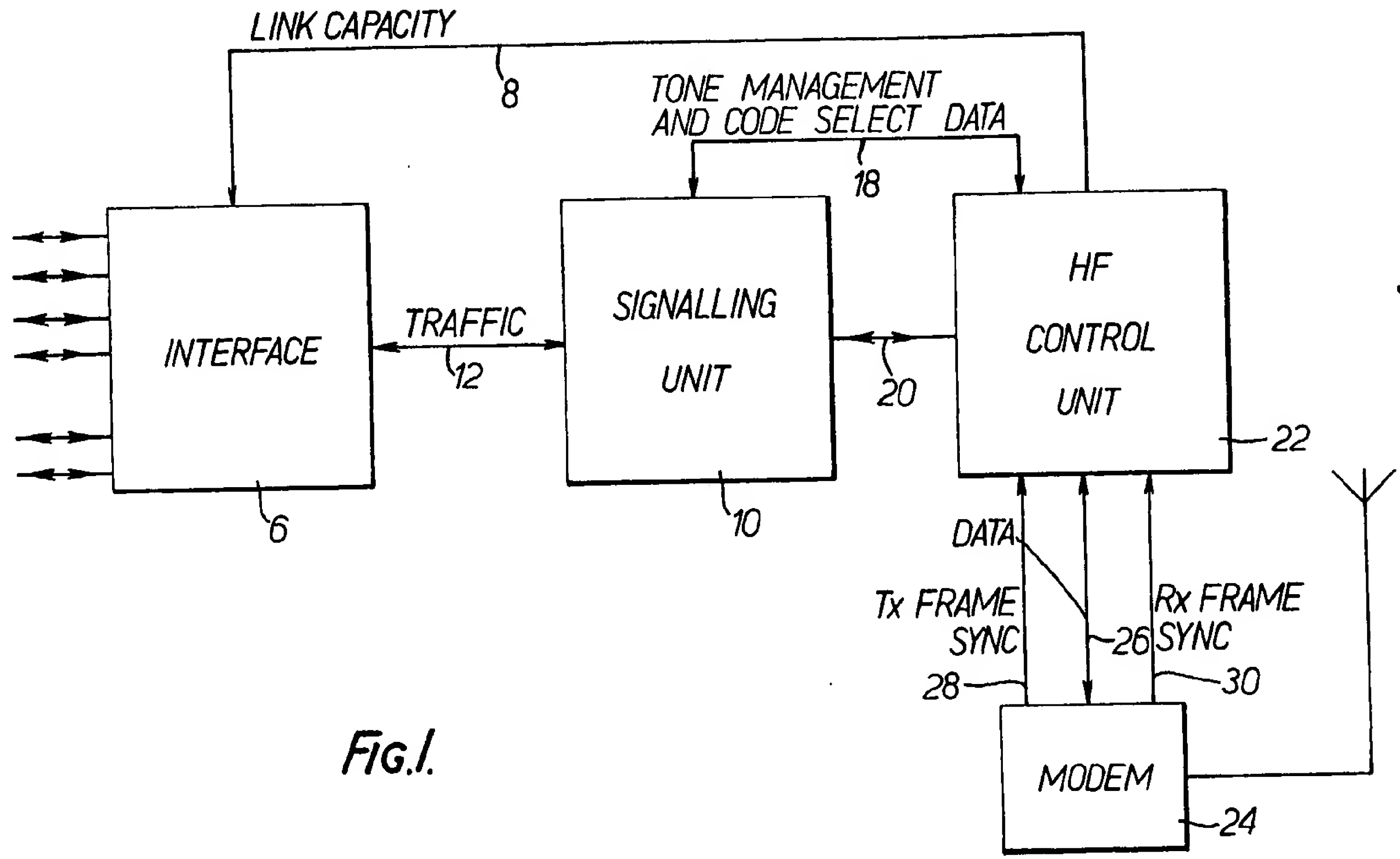
The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.



LINK CAPACITY
8
TONE MANAGEMENT AND CODE SELECT DATA
18
INTERFACE
6
TRAFFIC
12
SIGNALLING UNIT
10
20
HF CONTROL UNIT
22
DATA
Tx FRAME SYNC
28
26
Rx FRAME SYNC
30
MODEM
24

FIG.1.

2/4

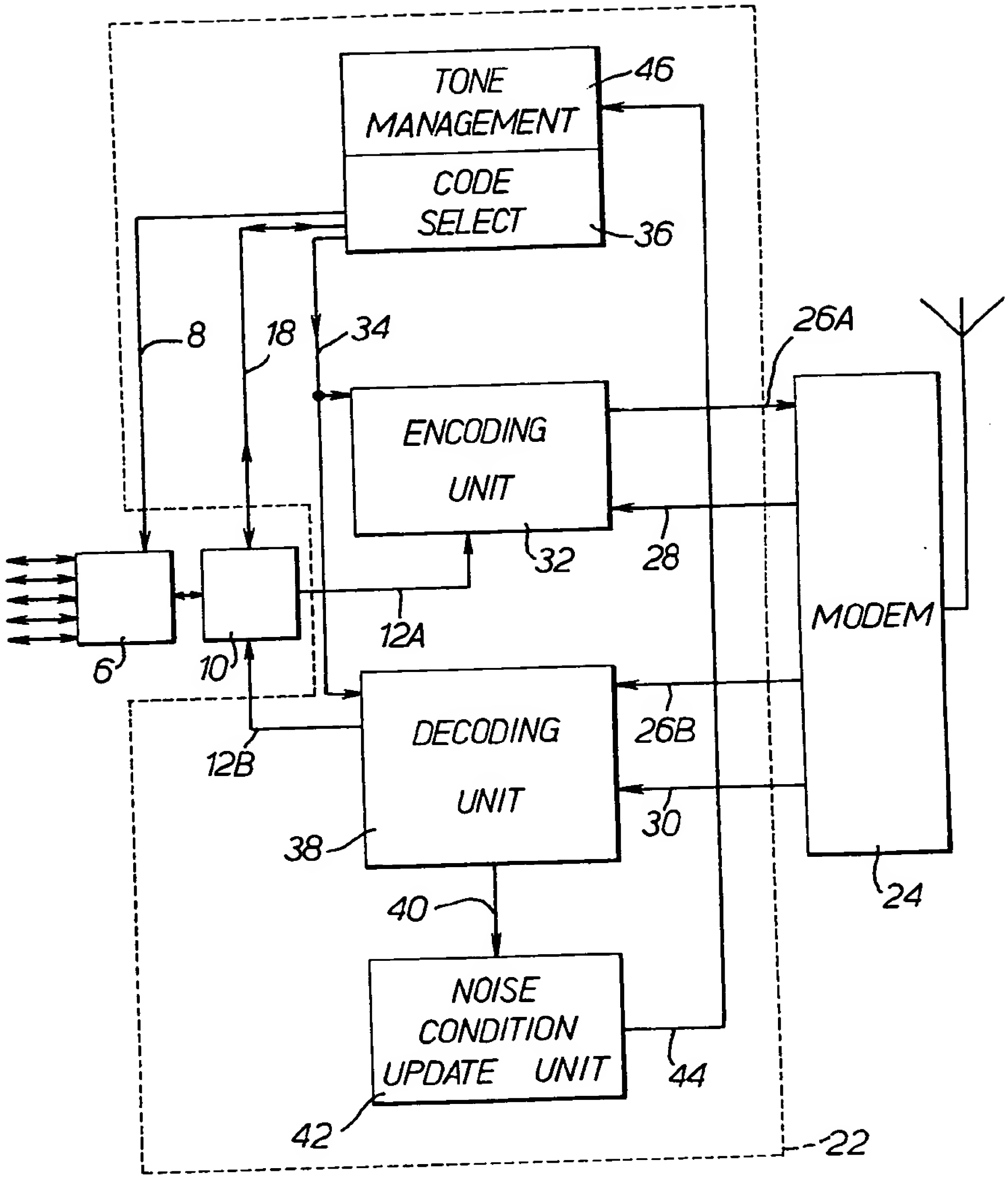

TONE MANAGEMENT
46
CODE SELECT
36
8
18
34
26A
ENCODING UNIT
32
28
6
10
12A
MODEM
DECODING UNIT
12B
26B
30
38
24
40
NOISE CONDITION UPDATE UNIT
44
42
22

FIG.2.

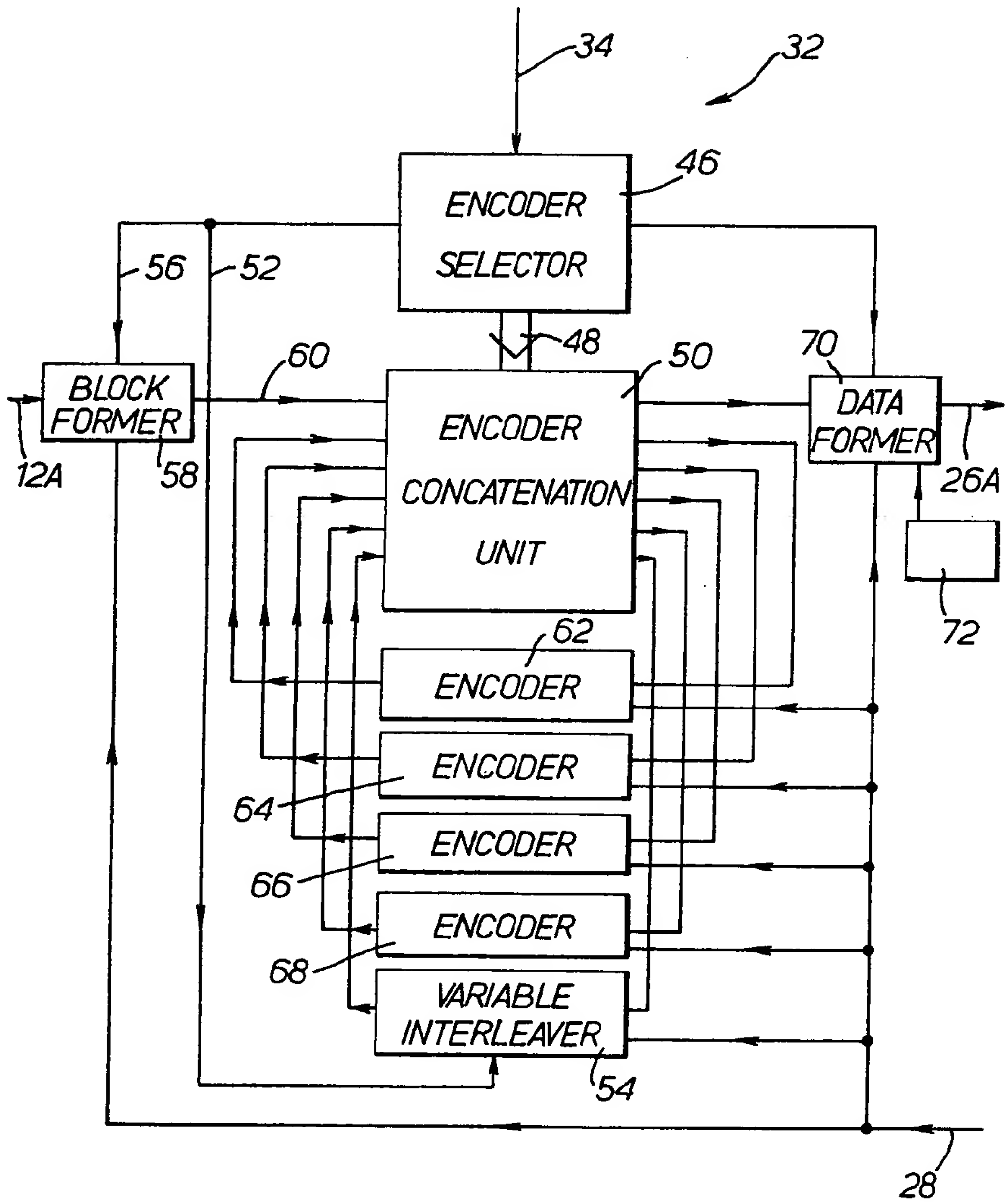

34
32
ENCODER SELECTOR
46
56
52
48
50
60
70
BLOCK FORMER
ENCODER CONCATENATION UNIT
DATA FORMER
12A
58
26A
72
62
ENCODER
ENCODER
64
ENCODER
66
ENCODER
68
VARIABLE INTERLEAVER
54
28

FIG.3.

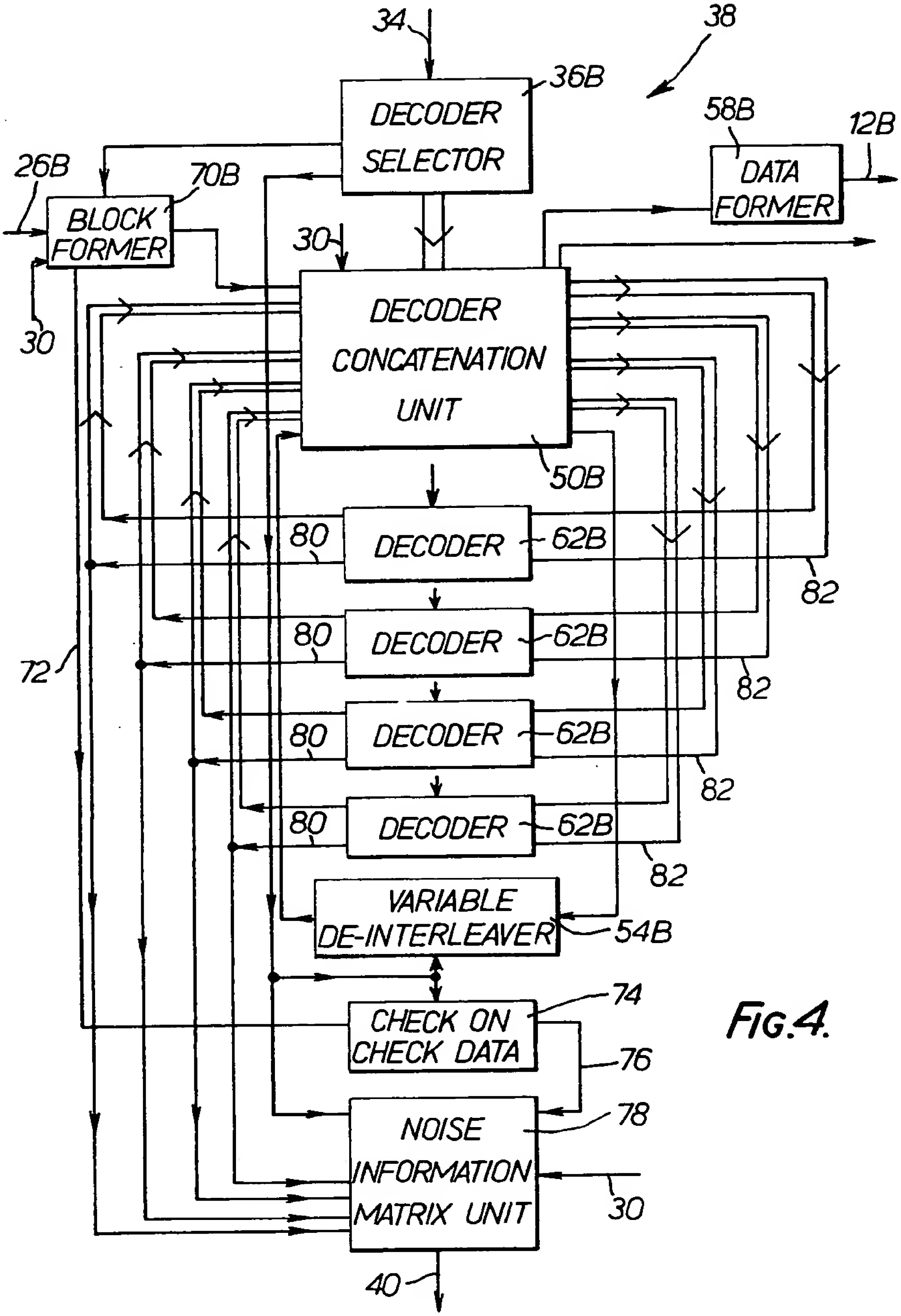

34
38
36B
DECODER SELECTOR
58B
12B
DATA FORMER
26B
70B
BLOCK FORMER
30
DECODER CONCATENATION UNIT
30
50B
80
DECODER
62B
82
80
DECODER
62B
72
82
80
DECODER
62B
82
80
DECODER
62B
82
VARIABLE DE-INTERLEAVER
54B
74
CHECK ON CHECK DATA
76
NOISE INFORMATION MATRIX UNIT
78
30
40

FIG.4.

SPECIFICATION
Data transmission

The present invention relates to methods and apparatus for transmitting digital data over radio links, in particular over HF radio links using parallel tone modems.

Sixteen tone parallel modems are known for use in HF transmission. An example of such a modem is the MAGNAVOX MX 513B which uses a 2.4Kbits/second baseband and differential phase shift keying (DPSK). This modem uses sixteen tones which are orthogonally spaced at 600 Hertz intervals. Two bits are transmitted at a time on each tone by selecting one of four possible phases for transmission of each tone frequency. Therefore the transmitted bit rate is 75 bauds to produce the overall transmission rate of 2.4Kbits/second. Such modems have been successfully used for the transmission of the digital output of a single vocoder to provide a single voice channel. At this data rate digitised voice transmissions are vulnerable to noise and for the transmission of data the level of integrity of the received signal is required to be much higher.

In order to provide for transmission of data over an HF link, it has been proposed to use forward error correction (FEC) or automatic requests for retransmission (ARQ). In some modems a fixed FEC code is available for use when data is to be transmitted. Since the type of interference present on the link may vary, such a code is likely either to be capable of dealing with much larger degrees of interference or to be inadequate for a large amount of the time. ARQ relies on detecting blocks received in error and requesting these blocks to be retransmitted. ARQ results in a relatively low overall transmission rate when the interference on the channel is high.

HF channels are subject to a variety of types of interference which result in errors being introduced into a data transmission using a parallel tone modem. Some sources of interference arise as a result of adverse propagation conditions. For example, flat-fading or data randomization can occur on all sixteen tones for short periods at a time. Both these effects appear as short periods of random errors simultaneously occurring on all tones. Selective signal fading and/or narrow band interference can cause randomization of the data on one or more tones. Wide band noise or interference is approximately equal on all tones and can be considered to represent an average bit error rate (BER) over the whole transmission. In any given situation all or only some of the above interference conditions may arise simultaneously at individually varying degrees of intensity. The prevalent interference conditions can, to some extent, be approximated as the sum of these three effects.

In prior art proposals for the use of FEC to improve the integrity of data transmission over such links, the codes proposed have been mainly intended for correcting random error distributions. For example modems have been provided with one type of short binary code for example a (16,8) Bose-Chaudhuri-Hocquengheim (BCH) code. Such a code is incapable of achieving good results against all the types of HF interference discussed. Moreover in prior art proposals the choice of code has been fixed or, at best, manually selectable. Such coding is unable to cope with the widely-varying conditions of the HF link, being either excessively redundant for all but the worst-case scenario or inadequate for all but the best-case scenario.

Advances have been made in the use of more complex error correcting codes. However, hitherto such codes have not been adapted or economic for use on HF links.

Modem designers have also tended to specify FEC as an add-on feature which is reasonably transparent to real-time users. In particular low redundancy and short time delays have become the main criteria for such code designs. With such limitations it is not possible to use coding techniques to their greatest effect.

In view of the above it will be appreciated that the technical problems of providing a system suitable for transmitting data with high integrity over links subject to interference such as HF links are considerable.

Accordingly, the present invention provides a system for passing data over a link subject to interference having a transmitter at one end and a receiver at the other end, the transmitter comprising coding means for coding data to be transmitted and a parallel tone modem for transmitting the coded data to the receiver, the receiver comprising a parallel tone modem for receiving the coded data received over the link, and decoding means for decoding received data, the system further comprising means for sensing the degree and type of interference prevailing on the link, and means for periodically reselecting the code or codes to be employed in the transmitter coding means and receiver decoding means in dependence on the output of the sensing means, and means for transmitting to the coding and decoding means data relating to the code or codes to be employed.

The data to be transmitted to the coding and decoding means may be either passed over a line where these means are at the same location as the reselecting means or transmitted across the link either by a separate reverse channel or preferably as in-band signalling with a symmetrical link operating in the reverse direction between two stations each being provided with a transmitter and receiver.

In a preferred embodiment the means for sensing the prevailing interference utilises information output from the receiver decoder on the position and number of errors corrected. Preferably this information concerning received data is processed and stored at each receiver. Periodically an assessment of the prevailing noise conditions is calculated and transmitted back to the original transmitter. This provides an economical feedback solution to the problem of diagnosing the interference conditions.

It will be appreciated that the code or codes to be used can be selected so that they are capable of dealing with the prevailing interference conditions on the link. The amount of data passed over the link

can then be maintained as high as possible given the prevailing conditions. In order to combat certain types of interference conditions, particularly flat-fading effects, a time delay must be imposed on the coded data in order to most efficiently overcome the interference and render the input to the decoder into a suitable form for the errors caused to be corrected. This time delay is normally caused by interleaving the data and this may be done to the minimum depth necessary to randomise the errors caused. However, this time delay need not be used unless required and therefore the time delay on the transmission of data overall is kept to a minimum.

In the present specification the term "codes" is intended to cover all the following techniques which are available to a preferred coding means:

Non-use of selected tones of the modem;

Interleaving the data to be transmitted to a selectable variable depth;

FEC codes such as: Reed-Solomon codes, Extended Hamming codes, Truncated BCH binary codes, Truncated Hamming codes, and Majority Voting;

Positioning of the encoded data upon the parallel tones in order to maximise decoder performance.

All these codes may be selectively concatenated and also may be of variable redundancy.

By concatenating one or more of the above codes together improved results may be obtained. For example Reed-Solomon codes are such that their performance is increased if used with another code such as BCH or Hamming code to diagnose the position of erased symbols, that is symbols which are known to be in error.

In a preferred embodiment the data is first encoded by a Reed-Solomon code and then by one or more binary codes. At the receiver the Reed-Solomon code is the last to be decoded. Preferably the placement of data on the tones of the parallel tone modem is preferably such that a binary codeword lies either entirely on one tone or across as many tones as possible.

The details of the performance and methods of coding and decoding using the above-mentioned codes will not be discussed in detail herein. It is possible to purchase or design suitable coders and decoders, and in most cases these can be implemented by means of suitably programmed microprocessors. Discussions of the properties and nature of such codes and their implementations can be found in the following references:

a) Macwilliams F. J. and Sloane N. J. A. "The Theory of Error Correcting Codes" published by North-Holland 1977, ISBN 0444 84009 0 1977;

b) Reed I. S. and Solomon G. "Polynomial Codes over Certain Finite Fields" J. Soc. Ind. Appl. Math. Vol. 8 pp. 300—304 June 1960;

c) G. D. Forney Jr. "Concatenated Codes" M.I.T. Research Monograph No. 37 1966;

d) Chien R. T. "Burst-Correcting Codes With High-Speed Decoding" Bell System Technical Journal, Vol 27 pp. 379—423, 623—656; and

e) Berlekamp E. R., "The Technology of Error-Correcting Codes," Proc. IEEE, Vol. 68, No. 5 May 1980 pp. 564—593.

Some embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:—

Figure 1 shows a block diagram of apparatus for transmitting data suitable for use at either end of an HF data link;

Figure 2 shows a block diagram of an HF control unit for use in the apparatus shown in Figure 1;

Figure 3 shows a block diagram of an encoding unit for use in the control unit of Figure 2; and

Figure 4 shows a block diagram of a decoding unit for use in the HF control unit of Figure 2.

Figure 1 shows a diagram representing a receiver/transmitter station for an HF link. The link is intended to transmit various channels of digital data. An interface 6 has several incoming channels connected to it. The interface 6 determines which of the incoming channels can be connected in dependence on the capacity of the link which is signalled to it by means of a line 8. The interface is connected to a signalling unit 10 to which it supplies on line 12 the traffic to be transmitted. The signalling unit 10 will not be described herein in detail. Its main function is to synchronise the coding at both ends of the link. The signalling unit also adds the signal tone management information which is to be transmitted across the link. This information includes information on the prevailing interference conditions. This information is received by the signalling unit 10 by means of a line 18.

The output of the signalling unit 10 is a traffic signal together with the required in-band signalling which is transmitted along a line 20 to HF control unit 22. The HF control unit 22 will be described in more detail later.

The output of the HF control unit is the encoded data in a form ready for transmission via the modem 24 to which it is connected by a line 26.

The modem is in this example an HF 16-tone parallel modem which outputs data at a maximum rate of 2.4Kbits/second. The modem 24 also outputs frame synchronizing information to the HF control unit by means of line 28 to enable the data to be supplied in the correct form.

During reception by the transmitter/receiver which may occur at the same time as transmission, the path of data through the station is reversed. The modem 24 then supplies received frames and synchronization data to the HF control unit 22 via lines 26 and 30 respectively.

The function of the HF control unit 22 is to select and apply a suitable form of coding which will combat the prevailing interference conditions on the HF link. The type of coding used does not in any way effect the operation of the modem 24 and provided this modem is provided with data at the correct rate and synchronization it operates independently of the code. Thus the HF control unit transmits 2.4K bits per second on line 26 and the modem sends it regardless of its structure.

More specifically, the HF control unit has the following functions:

1. At periodic intervals the noted interference conditions are used to ascertain the optimum

coding scheme and the usable tones and therefore the maximum link capacity which is signalled to the interface via line 8. Information on the interference conditions to be signalled to the other end of the link is also passed via line 18 to the signalling unit.

2. Encoding and decoding traffic under the prevailing scheme.

3. Processing the information on error location determined by the decoding element to provide measurements of interference conditions for use in function 1.

An embodiment of the HF control unit will now be described with reference to Figures 2 to 4 of the accompanying drawings. In Figure 2, the same reference numerals are used for the corresponding parts shown in Figure 1. However, where the referenced component relates to the transmission of data it is suffixed with a letter A and where it relates to reception of data the reference numeral is followed by a letter B.

Data to be transmitted is received by the HF control unit 22 from the signalling unit on line 12A and is fed to an encoding unit 32 which is shown in more detail in Figure 3. The operation of the encoding unit is determined by information received by it on a control line 34 from a coding selection circuit 36. The coding selection circuit 36 also provides the signal to be output on lines 8 and 18 to the interface 6 and signalling unit 10. The encoded data is fed along line 26A at a rate of 2.4Kbits/second to the modem 24 synchronized with the frame synchronization signal supplied from the modem on line 28.

Received data is fed from the modem 24 along line 26B to a decoding unit 30A. The decoding unit 30A also receives synchronization information along line 30 from the modem 24. The decoding unit also has an input along control line 34 from the coding selection circuit 36 which programmes the decoding to be carried out by the unit. The decoded data is output along line 12B to signalling unit 10. The decoding unit 38 also has another output along line 40 to a noise condition update unit 42. The output along line 40 relates to the number and location of errors detected in the received data during the course of decoding.

This information is processed by the noise condition update unit 42 to provide an indication of the type of noise being encountered by the transmission and this is fed along line 44 to the code selection circuit 36. The output of the code selection circuit regarding the codes to be used on the link is passed to the decoding unit and is sent along line 18 to be incorporated in the in-band signalling transmitted with the data across the link to the corresponding encoding unit at the other station.

The encoding unit 32 is shown in more detail in Figure 3. The input from the coding selector circuit 36 is fed along line 34 to encoder selector 46. The encoder selector 46 processes the received information and in accordance with predetermined criteria selects an appropriate code with which to encode the data to be transmitted which will overcome the prevailing interference conditions on the HF link. The code selected will be varied from time to time as conditions change. When a coding change is necessary a hand-shake procedure must be initiated across the HF link to ensure that both receiving and transmitting stations are using the same code. The exchange of information concerning errors detected and new codes to be used is incorporated into the in-band signalling via line 18. The requisite coding change can then be established automatically through programme control. As illustrated it is possible for the code selection circuit 36 to be connected to both the encoding and decoding units of its station. However it may be preferable to treat the two directions across the link between the stations separately so that a different coding scheme is used by the encoding and decoding links of one station. In this case the code selection circuit at each station governs only the code used by the decoding unit at that station and transmits back across the link as in-band signalling via line 18 the coding information required by the corresponding encoding unit at the other station. In this way if the apparent noise conditions are different in each direction different codes will be used.

The encoder selector 46 produces an output along a bus 48 to encoder concatenation unit 50 and also produces an output along a line 52 to a variable interleaver 54 to indicate the depth of interleaving required, and an output along a line 56 to an input block formator 58 to indicate the required input block size. Input data to be transmitted is received by the encoder unit along line 12A to the block formator 58. In the formator 58, the incoming data is divided into blocks of a suitable size for the coding scheme established. The data in the form of blocks is then fed along line 60 to the encoder concatenation unit 50. The encoder concatenation unit determines the sequence in which the data blocks are to be fed to the encoders 62, 64, 66, 68 and interleaver 54. The output of each encoder and also the output of the variable interleaver is fed back to the encoder concatenation unit 50 which feeds it to the next required encoder or the interleaver. The encoder concatenation unit determines to which and in what order the data is cycled through the encoders or variable interleavers to produce a suitable code adapted to the interference conditions on the link. The fully encoded data is then fed out from the encoder concatenation unit to a data former 70. The data former 70 receives the frame synchronization information from the modem on line 28 and uses this to arrange the data in a suitable structure. In one implementation the data former 70 places the concatenated symbols of a Reed-Solomon code on all the tones of a modem but arranges for the Reed-Solomon decoder at the other end of the link not to process the symbols on those tones considered to be blocked. In an alternative strategy the former arranges the encoded data so that when it is fed to the modem, all the encoded data is fed to usable tones whereas only check data, for example reversals, which is supplied from a source 72 is fed to those tones which are considered to be blocked. The output of the data former 70 is arranged to be at 2.4Kbits/second and is fed along

line 26A to the modem.

The frame synchronization is also fed from the modem 24 on line 28 to each of the encoders 62—68 and the variable interleaver 54 and also to the block former 58 so as to ensure that the data remains in synchronism with the operation of the modem.

The decoding unit 38 is shown in more detail in Figure 4. The decoding unit is similarly constructed to the encoding unit and similar parts have been referenced by the same reference numerals followed by a letter B. The received data from the modem is fed via line 26B to a block former 70B which operates under the control of an output from a decoder selector 36B. The block former 70B divides the data into the transmitted components from the usable tones which are fed to decoder deconcatenation unit 50B and the check data which was added from source 72. This check data is fed along line 72 to a check data circuit 74 which provides an assessment on line 76 to a noise information matrix unit 78 of the degree of interference on these blocked tones to establish whether they are still blocked or whether the bit error rate on these tones has dropped to a sufficiently low level for the tones to be brought back into service. The deconcatenation unit 50B routes the received data to the decoders 62B—68B and the variable de-interleaver 54B in the required sequence as dictated by decoding selector 36B. Each of the decoders decodes the code applied by the corresponding encoder in the encoding unit 32. The last applied code is therefore decoded first. The output of each decoder is fed back to the decoder deconcatenation unit 50B to be either recycled to a further decoder or the de-interleaver or out of the unit via a data former 58B and onto line 12B. Each of the decoders 62B to 68B has a further output 82 which relates to the error information determined by the decoding carried out in that decoder. This error information is fed back to the decoder deconcatenation unit to be fed to the next decoder in sequence via a further input 80 for each decoder, and also to the noise information matrix unit 78 where it is combined with the error information from line 76 to produce an output on line 40 which is fed to the noise conditions update unit 42 (Figure 2). The received frame sync on line 30 is fed to the noise information matrix unit 78, the block former 70B and the decoder deconcatenation unit 50B in order to ensure that these elements remain in synchronization together and also with the input from the modem. The error information input to the decoder on lines 80 is used in the decoding process in order to render that process more efficient. For example, for an RS symbol code if the decoder can be provided with information relating to erasures, that is symbols which are known to be in error, it is possible to correct more efficiently that data than if the position of it were not known.

It will be appreciated that the more redundant the coding scheme used, the less data it is possible to transmit. The modem is capable of transmitting a fixed output data rate of 2.4Kbits/second. If all the 16 tones are equally usable then the input data rate can take various values in dependence on the type of code used. As more or less tones become usable the selected output data rate changes by 150 bits/second for each tone. Alternatively all the tones can be used all the time. In such a system the last code to be decoded and the first code to be encoded is a Reed-Solomon code, implemented on a fast dedicated microprocessor. The other encoders protect each symbol of the Reed-Solomon code and the protected symbols are placed upon different tones. For example, the RS (16,12) code produces sixteen 4-bit symbols and one symbol is placed on each of the sixteen tones. A (8,4) code, for example protects each symbol, causing 8 bits to be placed on each tone. In this implementation, the (8,4) decoder also forms the check data circuit for the tones believed to be blocked. The RS decoder ignores the output from the (8,4) decoder for those tones believed to be blocked.

The encoders 62, 64, 66, 68 and corresponding decoders 62B, 64B, 66B and 68B may be software implemented by look-up tables for small binary codes or by dedicated fast microprocessors suitably programmed for the more complex codes. The interleaving and de-interleaving carried out by circuits 54 and 54B respectively are provided by means of a memory and input and output controls to give the required depth of interleaving.

As an example the encoder 62 and decoder 62B shown in the illustrated embodiment are arranged to implement a (16, 12) Reed-Solomon code operating on four bit symbols by means of a fast microprocessor. The encoder 64 and decoder 64B are arranged as look-up tables for implementing an (8,4) Extended Hamming code. Encoder 66 and decoder 66B each use a microprocessor together with look-up tables to implement a (12,4) Truncated BCH binary code, truncated from a (15,7) BCH code. The fourth encoder 68 and decoder 68B are look-up tables for producing a (12,8) Truncated Hamming code, truncated from a (15,11) Hamming code. The interleaver and de-interleaver are capable of operating to depths 1, 2, 4, 8, 16, 32 or 64.

The (16,12) RS code would always be used concatenated with one or more of the three other codes available to the system so that it could operate at maximum efficiency. All the above referenced codes are relatively short and therefore have limited efficiency but give relatively short time delays to the user of the system. These codes are also relatively easy to implement. Longer codes could be used to provide greater efficiency but the complexity of the encoders and decoders would increase.

As an example of the operation of the system, if 600bits/sec of actual data are to be transmitted and no channels are diagnosed as blocked because of narrow band interference or selective fading, a suitable coding scheme established by the code selector 36 and decoder selector 36B could be as follows. The block formater 58 is controlled via line 56 to divide the data into 48 bit blocks in the form of twelve four bit symbols. This formatted data is fed to the encoder concatenation unit 50 and then to encoder 62 where it is subjected to a (16,12) RS code which outputs sixteen four bit symbols which are

fed back to the concatenation unit and then to encoder 66 where each symbol is subjected to the (12,4) Truncated BCH binary code. This produces a codeword of 16 twelve-bit symbols from each input block. The codewords are then fed via the concatenation unit two at a time to the interleaver where the data is symbol interleaved to depth two. A greater depth of interleaving would require a larger number of bits to be fed to the interleaver at a time, increasing the time delay. The interleaver output which consists of 32 twelve bit symbols is then fed via the concatenation unit to the data former 70 which takes thirty-two bits at a time to transmit as a frame to the modem.

Other coding structures may be used to provide varying data rates which are possible if the BER of the link is higher. For example with no blocked tones a 300 bit/sec channel can be provided by using encoder 62 [(16,12)RS] followed by encoder 66 [(12,4) Truncated BCH] and then encoder 64 [(8,4)Extended Hamming code]. This may be followed by interleaving if the link is subject to multipath effects causing short periods of random errors. The degree of interleaving is dictated by typical lengths of virtually continuous strings of errors detected by the noise information matrix.

Where blocked tones are present there are two alternative strategies. In one strategy, the placement of the RS codewords is kept constant but the RS redundancy is increased. In this strategy the Reed-Solomon decoder is instructed not to process symbols on blocked tones, i.e. the symbols are treated as erasures. However, the binary codewords on blocked tones continue to be decoded to enable the Noise Information Matrix to monitor any improvement in the blocked tones. It will be appreciated that in the strategy the transmitter only has to know the required RS redundancy and choice of inner codes. The knowledge of which tones are blocked is not needed by the transmitter. This reduces the amount of information that needs to be transmitted back to the transmitter.

In the other strategy, the transmitter arranges for the encoded data not to be placed on blocked tones. Check data, for example reversals (0,1,0,1...) is placed on the blocked tones. The receiver decodes the data received on these tones and monitors the blocked tones for any improvement. In both these strategies interleaving may be used as required.

For example, if four tones are blocked and the throughput data rate is restricted to 300 bits/sec the encoder initially uses a RS (16,8) code on four bit symbols. Following this a (16,4) binary code is used on each symbol. The resulting sixteen 16-bit symbols are then processed into the parallel tone format such that one symbol only of each code word is placed wholly on each tone.

It will be appreciated that the codes may be combined in various ways to provide various data rates. The number and type of codes required to be concatenated is determined by the BER on the link. If this is low relatively more data may be transmitted by using fewer or smaller codes. The non-use or non-processing of some tones of the modem effectively deals with narrow band interference or selective fading affecting these tones. The degree of interleaving employed is determined by the flat-fading effects on the link. Information on these effects can be derived from the noise information matrix unit which accumulates the position of detected errors relative to the time of transmission and the tone on which the data was transmitted. Therefore if errors consistently occur on data transmitted on the same tone this tone can be diagnosed as blocked. If, at repetitive intervals, the performance of all tones degrades to give large groups of errors, this is indicative of flat-fading caused by multipath effects. The noise matrix also provides a measure of the BER.

It will be appreciated that various protocols may be used for amending the selected coding strategy. In one system the noise information matrix can be constantly compared with limits set by the coding scheme in use and if it is detected that the coding scheme is excessive or insufficient a hand-shaking procedure can be automatically set up with the other station to establish a new coding scheme to be used. The demand for capacity on the link is also a further factor in determining the coding scheme to be employed.

It will be appreciated that the criterion for selecting an appropriate coding scheme in dependence on the interference conditions may be varied according to the requirements of the link. The coders and decoders provided may also be changed to suit user requirements.

CLAIMS

1. A system for passing data over a link subject to interference having a transmitter at one end and a receiver at the other end, the transmitter comprising coding means for coding data to be transmitted and a parallel tone modem for transmitting the coded data to the receiver, the receiver comprising a parallel tone modem for receiving the coded data received over the link, and decoding means for decoding received data, the system further comprising means for sensing the degree and type of interference prevailing on the link, and means for periodically reselecting the code or codes to be employed in the transmitter coding means and receiver decoding means in dependence on the output of the sensing means, and means for transmitting to the coding and decoding means data relating to the code or codes to be employed.

2. A system as claimed in claim 1, wherein there is provided a station at each end of the link comprising a receiver and transmitter to provide two way communication across the link.

3. A system as claimed in claim 1 or 2, wherein the coding means applies concatenated codes to produce an output adapted to the transmission format of the parallel tone modem.

4. A system as claimed in claim 3, wherein the coding means first encodes the data with a Reed-Solomon encoder and the decoding means last decodes the data with a Reed-Solomon decoder.

5. A system as claimed in claim 4, wherein the coding means is adapted to connect at least one short binary encoder to the output of the Reed-

Solomon encoder and the decoding means is adapted to connect at least one short binary decoder prior to the Reed-Solomon decoder.

6. A system as claimed in claim 3 or 4, wherein the coding means comprises an interleaver and the decoding means comprises a de-interleaver.

7. A system as claimed in any one of the preceding claims, wherein the means for sensing the prevailing interference has an input adapted to receive information output from the decoding means on the position and number of errors corrected in received data during decoding.

8. A system as claimed in any one of the preceding claims, wherein the sensing means stores the information on the position and number of errors corrected, and further comprises means for making an assessment of the prevailing noise conditions on the basis of said stored information.

9. A system as claimed in claim 8, wherein the prevailing noise conditions taken account of in the assessment comprise random noise, selective frequency fading or interference, and periodic flat frequency fading or interference.

10. A system as claimed in any one of the preceding claims, wherein the reselecting means for the link is located at the receiver and the transmitting means for transmitting said data relating to code selection back from the receiver to the transmitter.

11. A system as claimed in claim 2, wherein the code or codes employed in each directions of the link between the stations are not necessarily identical, each being determined by the reselecting means associated with the decoder terminating that direction.

12. A communications transmitter and receiver station for transmitting and receiving data over a transmission channel subject to interference, the receiver/transmitter station comprising input means for receiving data to be transmitted, coding means connected to said input means for encoding the data to be transmitted, a modem having an input connected to the output of the encoding means, and an output which is transmitted, the modem also having an input for receiving transmitted data, and an output for received data, decoding means having an input connected to the modem output for received data, the output from the decoding means being received data, and frequency management and code selection means having an input from the decoding means representing information relating to the errors corrected during the decoding operation, said information being processed to determine the type of interference on the link, said frequency management and code selection means having an output connected to the encoding means and the decoding means to determine the code or codes to be used by the apparatus.

13. A communications station as claimed in claim 12, wherein said encoding means comprises a plurality of coders each having an input and an output, a concatenation unit having an input, and a block former having an input for receiving the data to be transmitted and arranging the data into blocks of a predetermined size adapted to conform to the format of the modem under the control of said code selection means, said blocks being output to said concatenation unit which operates under the control of said code selection means to feed said data to at least one of said coders in a predetermined sequence before outputting the encoded data, the input and output of each coder being connected to said concatenation unit.

14. A communication station as claimed in claim 12 or 13, wherein said decoding means comprises a plurality of decoders each having an input and an output, a concatenation unit, and a block former having an input for the received data and arranging the data into blocks of a predetermined size under the control of said code selection means, said blocks being output to said concatenation unit which operates under the control of said code selection means to feed said data to at least one of said decoders in a predetermined sequence before outputting the decoded data, the input and output of each decoder being connected to said concatenation unit.

15. A system for passing data over a link subject to interference substantially as herein described with reference to the accompanying drawings.

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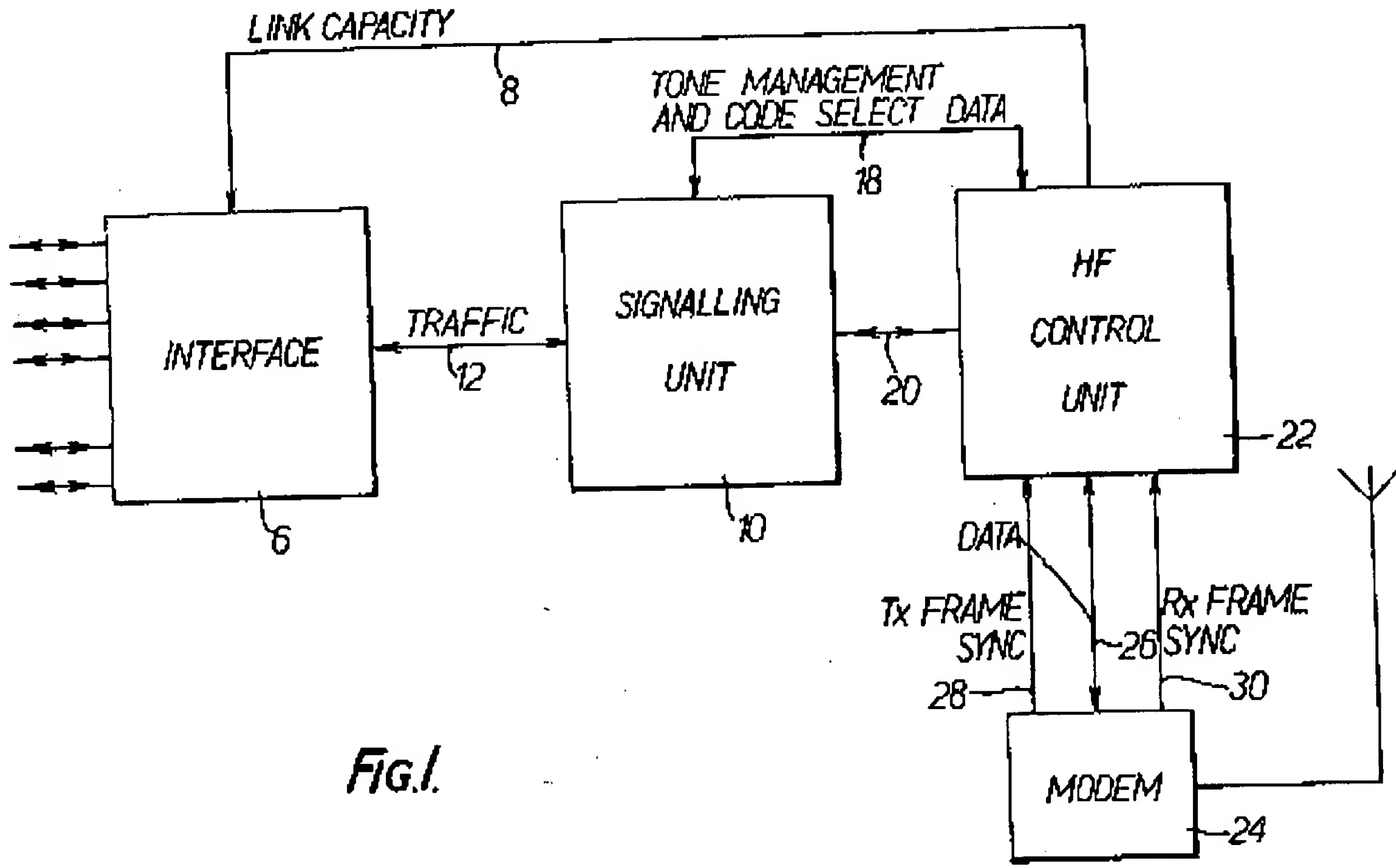

LINK CAPACITY
8
TONE MANAGEMENT AND CODE SELECT DATA
18
INTERFACE
6
TRAFFIC
12
SIGNALLING UNIT
10
20
HF CONTROL UNIT
22
DATA
Tx FRAME SYNC
28
26
Rx FRAME SYNC
30
MODEM
24

FIG.1.

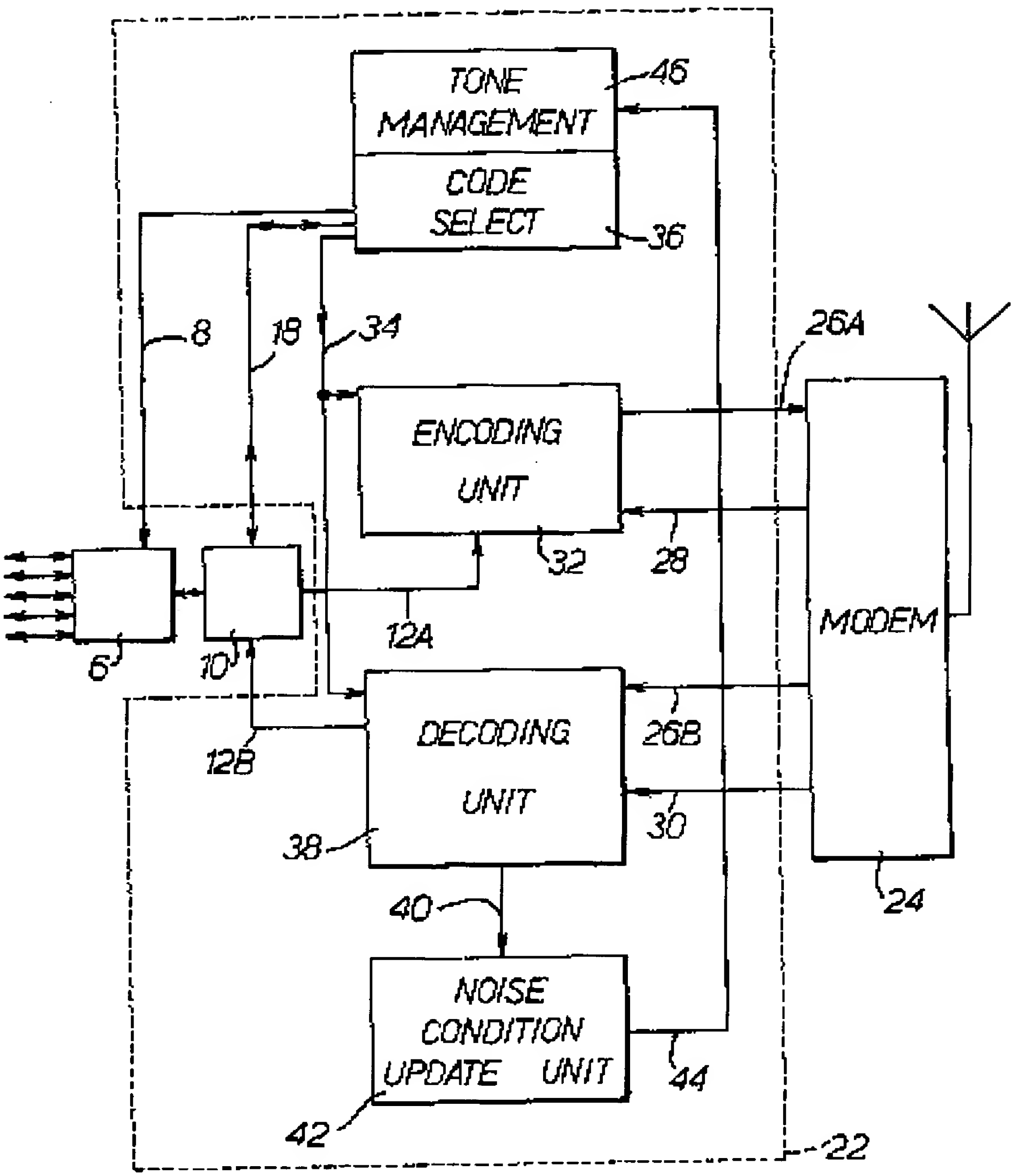
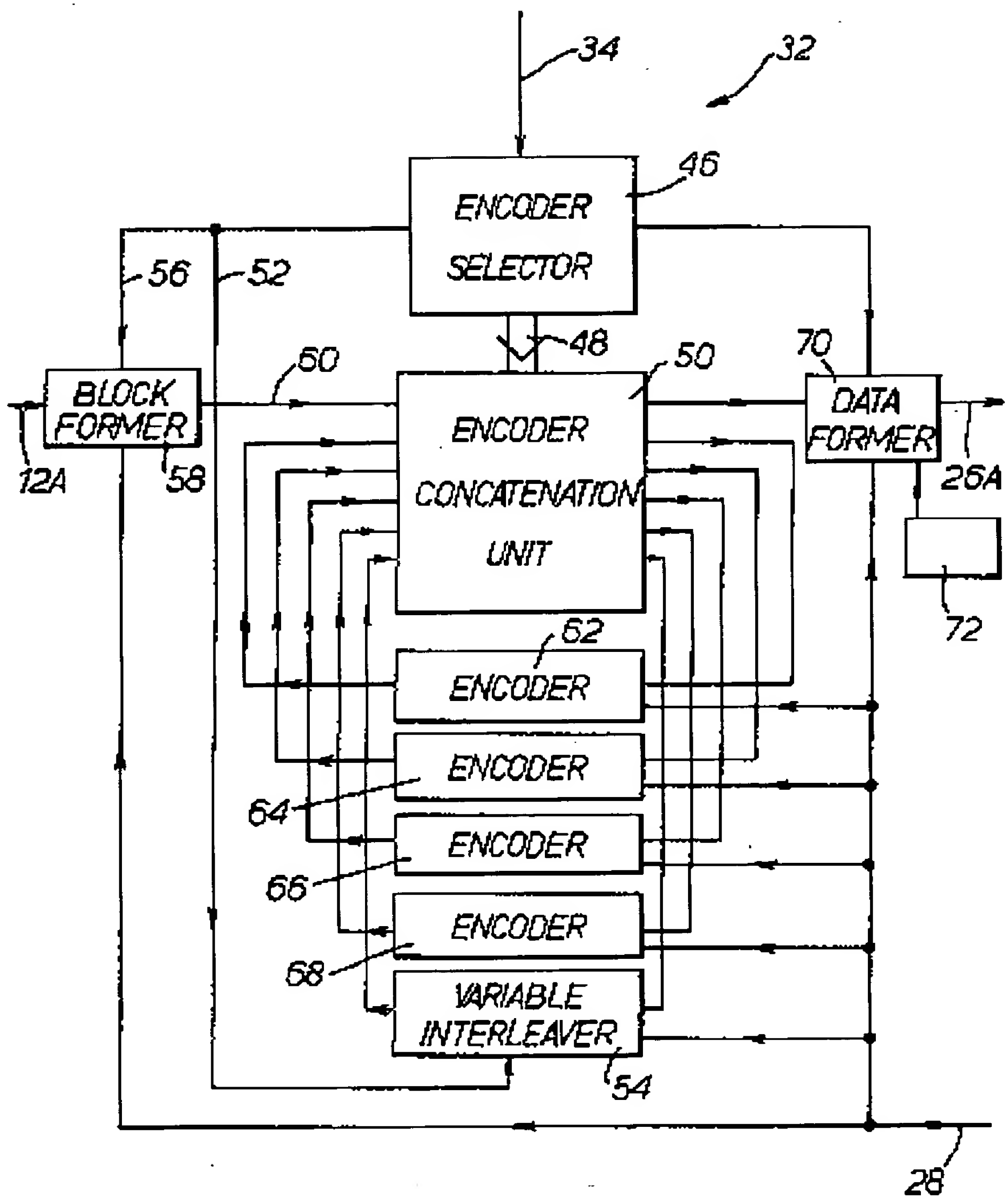

TONE MANAGEMENT
46
CODE SELECT
36
8
18
34
26A
ENCODING UNIT
32
28
MODEM
6
10
12A
DECODING UNIT
26B
12B
30
38
24
40
NOISE CONDITION UPDATE UNIT
44
42
22

FIG.2.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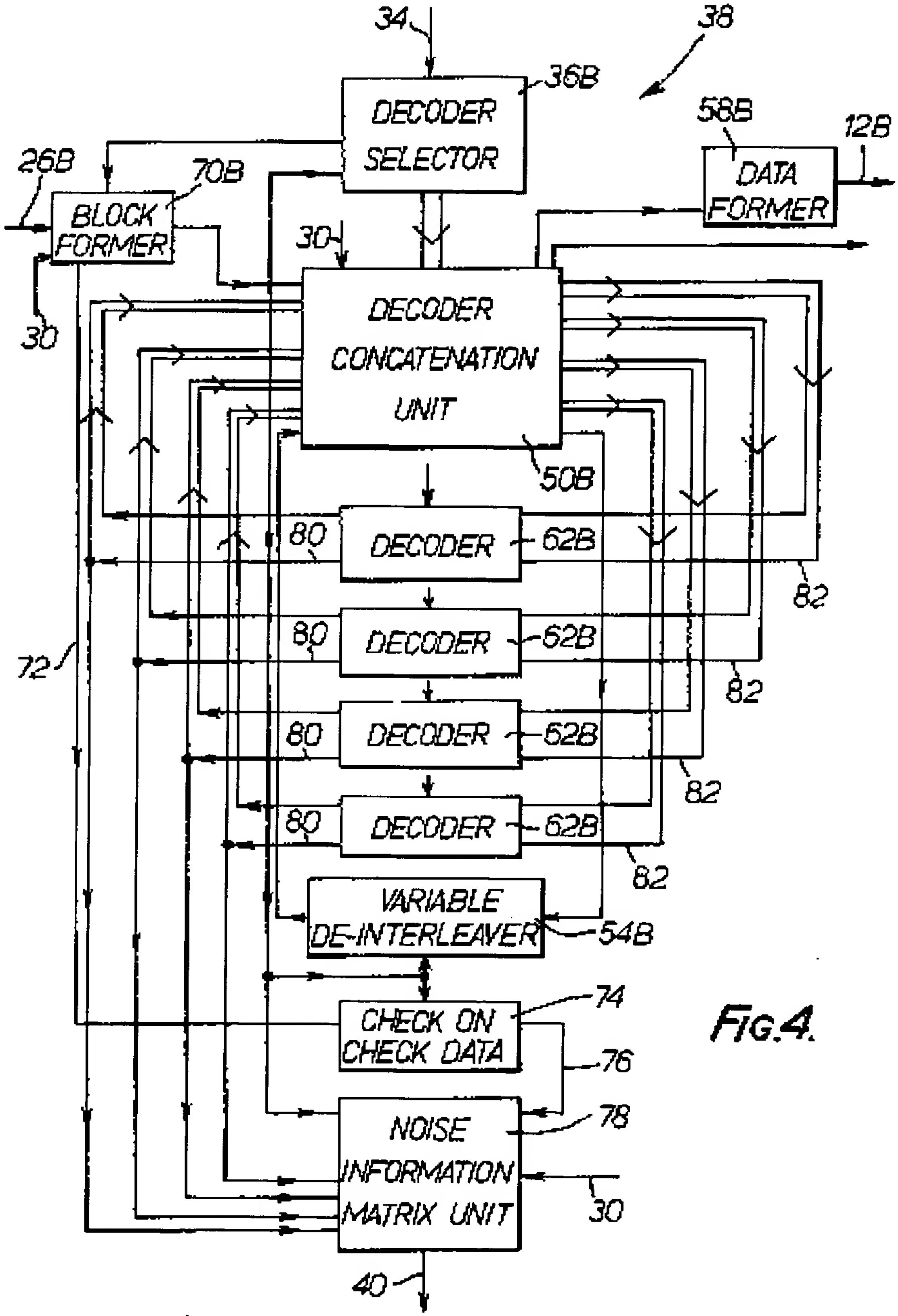
32
ENCODER SELECTOR
46
56
52
48
50
70
60
BLOCK FORMER
ENCODER CONCATENATION UNIT
DATA FORMER
12A
58
26A
72
62
ENCODER
ENCODER
64
ENCODER
66
ENCODER
68
VARIABLE INTERLEAVER
54
28

FIG.3.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38
DECODER
SELECTOR
36B
58B
12B
DATA
FORMER
26B
70B
BLOCK
FORMER
30
30
DECODER
CONCATENATION
UNIT
50B
80
DECODER
62B
82
72
VARIABLE
DE-INTERLEAVER
54B
CHECK ON
CHECK DATA
74
76
NOISE
INFORMATION
MATRIX UNIT
78
40

FIG.4.

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